MANAGEMENT PRACTICES OF DEVELOPING HEIFERS AFFECTS LIFETIME PRODUCTIVITY

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Introduction

The manner in which replacement heifers are managed during development has an impact on their lifetime productivity. Because beef production occurs across a wide range of environments and under many different production objectives, it is important for this presentation to focus on management practices that are somewhat "environment neutral". Therefore, I will focus primarily on fundamental principles related to heifer management and approaches that have proven beneficial under many different scenarios.

Heifer Management to Produce Early Calving Cows

As a boy, I recall my dad saying "Once an early calver, always an early calver". While Dad may have been exaggerating when he used the word "always", this fundamental principle has stuck with me and I accept it as a truism.

Principles from the 1950s and 60s in Montana (Lesmeister et al., 1973)

An oft quoted study, to document the relationship of relative date of first calving compared to herd mates and subsequent calf production, was published in Journal of Animal Science in 1973 – forty years ago – by Lesmeister, Burfening and Blackwell (Lesmeister et al., 1973). I quote the summary from that article:

> *"A study was made of the effect of relative first calving date in beef heifers on lifetime production using production records from two beef herds[Bozeman and Havre, Montana]. The study involved 2036 spring calves [born] from 481 cows weaned in October or November of each year. An initial calving group was determined for each heifer based on the relative birth date of her first calf. A subsequent calving group was similarly assigned to each additional calf from the same cow. Heifers calving initially in the early, first and second groups tended to calve earlier throughout the remainder of their productive lives than heifers calving initially in later groups. However, repeatability estimates for calving group in the two herds were 0.092 and 0.105 indicating that only moderate improvement might be made by culling cows that calve late during the normal calving season. Calves born in earlier groups grew significantly faster from birth to weaning and weighed more at weaning than calves born in later groups. Lifetime production was significantly affected by initial calving group. Early calving heifers had higher average annual lifetime calf production than late calving heifers. This study indicates the importance of managing and breeding heifers so they will calve early in the season and thus tend to maintain early calving throughout their*

productive lives. Such management should contribute profit in the cow-calf operation.” (Lesmeister et al., 1973)

As mentioned, this study is frequently quoted since it describes and documents the benefits of managing heifers to calve in the first 21 days of their first calving season. Let’s explore a few of the fundamental management principles that can be gleaned from this study and apply them to current opportunities in heifer development.

Principle #1 (Lesmeister) – Heifers that conceive early as yearlings during their first breeding season appear to be “programmed” for productive lives. The summary paragraph of this article demonstrates the wisdom of the authors in setting the stage for many of the management practices used in the beef industry currently. Today, the term “programmed” is frequently used in connection with “fetal programming”, or the impact that the maternal environment plays on the performance of the individual throughout its life. The author’s use of the term “programmed” did not encompass today’s fetal programming meaning, but it is insightful that even in 1973 it was suggested that preparing heifers for early calving by nutrition and selection was a recommended practice. Here is a portion of the concluding paragraph:

“[T]hese data indicate the importance of managing first-calf heifers for early calving in the optimum season in herds with a limited breeding season and a definite time of weaning. A larger proportion of replacement heifers than needed should be bred, pregnancy tested and culled at the end of the breeding period if they are open. The heifers that conceive and calve the earliest immediately indicate their greater reproductive efficiency and lifetime potential. They should be given some preference in selection. The proper application of selection for rapid growth and early sexual maturity in yearling beef heifers and adequate nutritional regime are essential for "programming" beef cows for early, regular calving throughout their productive lives.” (Lesmeister et al., 1973)

Principle #2 (Lesmeister) – Early-born calves performed better than later-born calves. The Lesmeister study was done with spring-calving cows in native range grazing environments near Bozeman and Havre, Montana (MT). The breeding season at Havre began approximately June 15 each year of the study and lasted for 60 days. The length of the breeding season at Bozeman ranged from 10 to 133 days. Weaning occurred each year in October and November across the 19 years at Bozeman and 15 years at Havre that were studied. The reported results for calf performance were:

“The calving group [early, mid or late] for a particular calf had a highly significant (P< .01) effect on its performance from birth to weaning. Calves born earlier in the normal season weighed more at weaning than later calves due to their older age and their faster rate of pre-weaning gain.” (Lesmeister et al., 1973)

Calf survival from birth to weaning at Havre was also enhanced if calves were born early in the calving season.

"Calving group significantly (P<.01) affected the percent of calves surviving from birth to weaning in the Havre herd but not in the Bozeman herd. The percent survival declined continually for each 21 days later that calves were born during the calving season at Havre." (Lesmeister et al., 1973)

Higher survival rate and greater weaning weights combined to improve the lifetime productivity of the cows. The authors emphasized this outcome when they stated:

"One of the most important findings of this study was the fact that cows calving early the first time produce more kilograms of calf (P<.01) in their lifetime than cows calving later the first time… Most of the difference in average annual lifetime production was associated with increased production at the first calving." (Lesmeister et al., 1973)

Principle #3 (Lesmeister) – Release of dominance expressed as heterosis in reproductive traits is real. The cow records in this study were collected during the 1950's and 1960's and included purebred Angus and Hereford cows in Bozeman and four different closed lines and one crossline of Herefords at Havre. The Havre crossline Hereford cows (line 5) resulted from mating line 1 cows with line 4 cows to evaluate the release of linebreeding dominance. The results of this crossing were:

"…cow line…significantly (P<.01) affected birth weight, weaning weight and ADG of calves…There was a consistent and statistically significant difference among the cow lines at Havre for all of the production traits analyzed. The crossline cows [line 5] consistently showed better performance than the straight line cows and earlier initial calving groups than the mean of straight line cows. The calves had heavier birth weights, heavier weaning weights, older weaning ages and higher average daily gains than the straight line calves. Inbreeding depression and heterosis were evident." (Lesmeister et al., 1973)

As noted, this study dealt with straightbred cows and cows of the same breed (Hereford) in a cross with selected lines. Numerous additional studies have clearly shown heterosis for reproductive traits when breeds are crossed. For example, Cundiff (Cundiff, 1970) reported the results of projects conducted by W-1, NC-1 and S-10 animal breeding regional committees. The reported conclusions from this report (Cundiff, 1970) identify the advantages of heterosis on reproductive traits as follows:

"…the major benefit will be accrued through the cumulative effects of heterosis on fertility, maternal ability and growth rate. It appears conservative to conclude that production per cow exposed for breeding can be increased 20 to 25 % by systematic crossing of British breeds. About half of this advantage is dependent upon the use of crossbred cows to take advantage of heterosis for maternal ability and reproduction."(Cundiff, 1970)

The advantage in herd survival rate to 12 years of age and longevity for crossbred cows compared to straightbred cows was reported by Núñez-Dominguez et al. (1991) from the population of Angus, Hereford and Shorthorn first-cross cows in the animal breeding regional projects described above by Cundiff (1970). Núñez-Dominguez et al. (1991) concluded:

> *"Survival of cows is an important component of lifetime productivity measured as the total calf weight weaned per initial replacement female. Longevity is an equivalent measure of cumulative survival at some final age. In either trait, performance of crossbreds was higher than that of straightbred cows. Thus, crossbreds needed fewer replacements than straightbreds and had a lower culling rate at any age." (Núñez-Dominguez et al., 1991)*

Effect of Calving Distribution on Progeny Performance

The objectives of the Lesmeister paper published in 1973 from cows in the 50s and 60s discussed above were investigated recently in a paper by Rick Funston and co-workers (Funston, et at., 2012) in cows in Nebraska. The Funston paper reported on records from 1997 to 2010 for steer and heifer progeny from composite cows (Red Angus x Simmental) at the Gudmundsen Sandhills Laboratory, Whitman, Nebraska (NE). These two studies report on different environments (MT vs. NE), different breed-types (straightbred AN and HH vs. crossbred), and across a 40 to 50 year difference in time. Funston and co-workers also collected more detailed information, including feedlot and carcass characteristics of steer progeny and reproductive traits of heifer progeny, than Lesmeister and co-workers. This is expected with advances in sophistication of research approaches over the past 40 years since 1973. However, the outcomes of the importance of cows calving early in the calving season are very similar.

Principles from the 1990s and 2000s in Nebraska (Funston, et at., 2012)

In the introduction of the Funston paper (Funston, et at., 2012) the authors review additional advantages seen in other research reports as related to retention of cows in the herd and the influence of preweaning growth on puberty.

> *"Calving date can also influence the number of cows calving the next year. Cows that calved late 1 yr tended to calve late or not calve the next year (Burris and Priode, 1958; Kill et al., 2012). In a review by Patterson et al. (1992), data are cited from the 1950s to early 1980s, indicating preweaning growth exerts a greater influence on puberty than postweaning growth." (Funston, et al., 2012)*

Principle #4 (Funston) – Heifers born early in relation to herdmates, increases the likelihood that they will conceive early in their first breeding season. Funston and co-workers followed the heifer progeny through development and their first breeding and calving seasons.

> *"Percentage of heifers cycling at the beginning of the breeding season decreased (P < 0.01) with advancing calving date (70, 58, and 39%, respectively) and 45 d pregnancy rates were*

lowest ($P = 0.02$) for heifers born in the third calving period (90, 86, and 78%, respectively)." (Funston, et al., 2012)

Dunn and Kaltenbach (1980) point out that females conceiving early in the breeding season result in increased postpartum recovery period the following year, thus increasing the probability of early conception again.

Principle #5 (Funston) – Early-born heifers tend to have early calves themselves. It is interesting, though not surprising, that heifers born as first calf progeny tended ($P \leq 0.10$) to have the greatest weaning weight if they were born to a heifer that was born in the first calving period. Thus, there was a generational advantage for early calvers.

"…more ($P < 0.01$) calves were born in the first 21 d of the calving season if the heifer herself was born in the first calving period." (Funston, et al., 2012)

Principle #6 (Funston) – Steer progeny from early calving cows produce higher value carcasses than late calving cows. The Funston study reported that steer progeny also displayed an advantage if they were born during the early portion of the calving season when compared with later born steer progeny.

"Carcasses of earlier born steers were more valuable on a [body weight] basis and received a greater premium on a carcass basis than later born steers." (Funston, et al., 2012)

A summary of the results reported in the Nebraska study is explained in the implications section of the Funston article as follows:

"Heifer calves born during the first 21 d of the spring calving season had greater weaning, prebreeding, and precalving [body weight]; greater percent cycling before breeding; and greater pregnancy rates compared with heifers born in the third calving period. First calf progeny from heifers born in the first 21 d of the calving period also had an earlier birth date and greater weaning [body weight]. Calving period of heifer progeny significantly impacts development and first calf characteristics. Steer calves born earlier in the calving season have greater weaning [body weight], [hot carcass weight], and marbling scores. Increasing early calving frequency may increase progeny value at weaning and enhance carcass value of the steers. Managing groups of heifer and steer progeny by calving date may allow for more efficient use of resources and optimize reproductive performance of heifer calves and feedlot performance of steer calves." (Funston, et al., 2012)

Lifetime productivity has been shown to be greater in heifers managed so they calve early their first calving. This results from both older and faster growing calves that are born early relative to later-born herdmates. Advantages of early-born calves are perpetuated by greater pregnancy rates at first mating in early-born heifers and greater carcass value in early-born steer calves.

Differences in Lifetime Productivity of Heifers Conceived by AI or Natural Service

A study done by Colorado State University and recently published (French et al., 2013) evaluated 6,693 records from 1,173 females at the CSU John E. Rouse Beef Improvement Center **(BIC)** located in Saratoga, WY. The objectives of the study were: 1) determine the effect of conception to AI or natural service **(NS)** as yearlings on lifetime productivity, and 2) compare lifetime productivity among females that were the offspring of an AI or NS sire.

In herds that use AI, such as BIC, it is a standard practice to conduct AI at the beginning of the breeding season, and follow later with clean-up bulls for natural mating. Therefore, the opportunity for NS sires to produce early born calves is compromised under these circumstances. It is also quite common for heifers to be synchronized for estrus in some manner when AI is part of the ranch management practice. This practice will also skew the data for AI toward the early part of the calving season compared to non-synchronized breeding with either AI or NS. Since both of these practices were used at BIC in the data reported by French et al. (2013) we must recognize that the results likely contain a bias toward AI.

As further explanation of the CSU study, each year yearling heifers were inseminated 3 to 4 weeks before the cows. This is also a common industry management practice. As a result of this practice the production records from the dams at BIC were classified into 4 different categories: 1) heifers that conceived to AI **(H-AI)**, 2) heifers that conceived to NS **(H-NS)**, 3) cows that conceived to AI **(C-AI)** and 4) cows that conceived to NS **(C-NS).** This delineation was made to isolate the effect of the parity of the dam of a female on its lifetime productivity. In addition, due to the genetic objectives at BIC related to investigation of high-elevation (brisket) disease, the same sires used for AI were used for NS with the heifers; different AI and NS sires were used with the cows.

Lifetime revenue from females in the CSU study was estimated using the sum of the weaned calf value for all calves produced by these females. Calf value was computed based on local auction market prices over the period from 1991 to 2010. These estimates reflected varied prices for various weight and sex classes. Using this approach, it was possible to compute lifetime revenue for each female category of females (H-AI, H-NS, C-AI, and C-NS) as classified above.

The overall purpose of the present paper is to discuss the effect of management practices of developing heifers on lifetime productivity. There are some additional principles that can be drawn from the CSU study (French et al., 2013) to add to the work of Lesmeister and Funston already discussed.

Principle #7 (French) – Yearling heifers that respond to estrus synchronization and conceive early to AI produce greater lifetime revenue than heifers that conceive to natural service. When Lesmeister et al. (1973) published their study on cow records from the 1950s and 1960s, estrus synchronization was not done, other than experimentally. Therefore, as Lesmeister and co-workers point out in their publication, "All cows could not be expected to be in estrus the first day of the breeding season due to the length of the estrous cycle." With advances in estrous cycle management over the intervening 50 years, it is common, especially in heifers, for a high percentage of synchronized females to be in estrus on the first day of the breeding season. The majority of females that are not in estrus in synchronized herds are not cycling – either due to being non-pubertal or anestrus cows. In cows, anestrus likely results from short postpartum intervals at the beginning of the breeding season in later calving cows.

> *"Females that conceived to AI as a yearling were older and heavier (P = 0.02) at the time of AI than were females that conceived to a clean-up bull via NS. Females that conceived to AI as a yearling also had greater (P = 0.04) average weaning weight for calves produced during their lifetime and weaned more (P < 0.0001) weight and more (P < 0.0001) total calves throughout their lifetime than did females that conceived to NS as a yearling [Table 1]." (French et al., 2013)*

Table 1. Measures of heifer's own performance and summarized performance of its calves among females that conceived at AI or natural service (NS) as yearlings.

	Performance of heifer				Performance of progeny		
Conception Classification	n	Age of heifer at 1st AI (d)	PPI[1] (d)	Lifetime revenue[2] ($, actual price basis)	n	Lifetime weight weaned (lb)	Lifetime calves weaned
Conceived to AI	871	429[a]	92	$2,483	4,530	2,363[a]	5.2[a]
Conceived to NS	302	418[b]	87	$1,561	909	1,398[b]	3.0[b]
Difference		11	5	$922		965	2.2

[a,b] Means within a column without a common superscript differ ($P < 0.05$).
[1] PPI = postpartum interval; defined as the number of days between the calving date of the female and the subsequent date of AI. This number is the average PPI across all years that the female was in the herd.
[2] Lifetime revenue produced per female was calculated using prices from Torrington Livestock Market LLC (Torrington, WY) from 1991 to 2010. See original manuscript for further explanation of how this was calculated.

The use of AI in beef herds allows use of proven sires with documented genetic merit. Lamberson et al. (1993) stated that AI offers the advantage of making available many sires with outstanding genetic merit, a situation that would not be economical for most commercial producers for use in NS. As noted above, heifers at BIC were mated to the same sires AI and NS, therefore, some of the potential advantages of AI compared to NS are not fully reflected in the article by French et al. (2013). As further explanation why this was done at BIC, the authors state:

> *"One of the goals of the BIC was to produce seedstock Angus bulls specifically adapted to high-altitude environments. Because of this, ranch management inseminated heifers to bulls produced by the ranch and then used these same bulls via NS on their females. This facilitated genetic improvement of the herd while also using sires that could perform in*

the environment. This decision to AI heifers to the same bulls used for NS is noteworthy because it reduced some of the benefit of using elite genetics through AI but also reduced the risk of introducing genetics that were not adapted to the high-altitude environment. The average weaning weight of calves from females conceiving to AI may have been greater if outside sires with improved genetics for growth had been used (Ellis, 2005) but also would have increased the risk of mortality in offspring associated with nonadapted genetics." (French et al., 2013)

However, the advantage of females conceiving to AI was demonstrated indirectly due to earlier conception in both females that conceived to AI and those sired by AI when compared to NS (Table 2.) This table reports the female's response, based on the dam classification, based on age of dam and whether progeny resulted from AI or NS.

Table 2. Measures of female's own performance and performance of calves by dam classification.

	Performance of female				Performance of progeny		
Dam Classification[1]	n	Age of heifer at 1st AI (d)	PPI[2] (d)	Lifetime revenue[3] ($, actual price basis)	n	Lifetime weight weaned (lb)	Lifetime calves weaned
H-AI	195	450[a]	88	$2,223	926	2,147	4.6
H-NS	40	421[b]	88	$1,949	175	1,918	4.2
C-AI	618	427[b]	87	$2,253	2,928	2,129	4.7
C-NS	320	403[c]	84	$2,313	1,454	2,180	4.7

[a,b,c,d] Means within a column without a common superscript differ ($P < 0.05$).
[1] H-AI = female born to a primiparous heifer and the offspring of an AI mating; H-NS = female born to a primiparous heifer and the offspring of a natural service (NS) mating; C-AI = female born to a multiparous cow and the offspring of an AI mating; C-NS = female born to a multiparous cow and the offspring of an NS mating.
[2] PPI = postpartum interval; defined as the number of days between the calving date of the female and the subsequent date of AI. This number is the average PPI across all years that the female was in the herd.
[3] Lifetime revenue produced per female was calculated using prices from Torrington Livestock Market LLC (Torrington, WY) from 1991 to 2010. See original manuscript for further explanation of how this was calculated.

French et al. (2013) summarized the results of their study in the implications section of their paper as follows:

"Replacement females that conceive earlier in the breeding season, accomplished via the use of estrus synchronization and AI, have increased longevity. Furthermore, estrus synchronization with AI can be an effective management tool to produce replacements that are older at breeding, become pregnant early in the breeding season, and have the potential to consist of superior genetics." (French et al., 2013)

Summary

The primary focus of this paper has been on the benefits of managing heifers to conceive early in their first breeding season. This practice produces cows that have greater lifetime productivity due to more growing days of their progeny before a set weaning date, which results in greater weight weaned. It also provides for longer postpartum intervals to prepare for the subsequent breeding season, therefore increasing the probability of conception early in the breeding season to facilitate early calving the next calving season. Combined, these factors result in greater lifetime productivity of heifers that calve early relative to herdmates.

The use of estrus synchronization and accompanying AI are tools available to increase lifetime productivity and facilitate earlier calving.

Over the past several years, the traditional practice of developing replacement heifers to a target weight of 65% of expected mature weight has been questioned. Funston and Deutscher (2004) and Funston et al. (2011) reported that prebreeding rate of gain has minimal effect on heifer pregnancy rate. This has led to changes in management by some producers in an attempt to reduce input costs for heifer development while not compromising reproductive performance.

Approaches such as developing heifers at a rate of gain and target weight at first breeding lower than traditionally used (55 vs. 65% of mature weight) appear to be a viable practice for heifers with improved genetic merit for growth and reproduction available in today's beef industry. In addition, exposing a higher number of heifers during a short breeding season and retaining pregnant heifers into the herd will serve to improve the lifetime productivity of heifers.

The principles outlined in this paper will allow producers to identify heifers that match the production environment and contribute to having early calving cows in the herd.

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